High Performance Computing Summer Institute: Foundation of Faculty/Student Technological and Scientific Investigations

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Abstract

The High Performance Computing Summer Institute (HPCSI) at Morgan State University has provided a platform for the enhancement of faculty and student development and research opportunities in the investigation of technological and scientific phenomena. This eight-week program is designed for undergraduate students to engage in research with a faculty mentor while employing leading edge technologies to solve a wide range of problems in science, engineering, and mathematics (SEM). Over the past five years, the HPCSI has evolved into one that is national in scope representing students and faculty from universities in the Baltimore-Washington region and a number of historically black colleges and universities (HBCUs). Initially funded by the National Science Foundation with strong in-kind support from the National Aeronautics and Space Administration Goddard Space Flight Center (NASA GSFC) and MUSPIN, the HPCSI now leverages resources from other federal agencies, including DoD and DoE. In this paper, the ideas and concepts behind the establishment of the HPCSI and the role that it has played in preparing undergraduate students for greater challenges of high technology employment and entrance to graduate schools are discussed. An extrapolation of how this model might be extended to include participation from more HBCUs and Tribal Colleges will be posed. Examples of the research topics that have emanated from the activity will be presented.

1.0 Introduction

In 1993, Morgan State University and other coalition members of the Washington-Baltimore Hampton Roads Alliance (WBHR) successfully received funding from the National Science Foundation (NSF) that was designed to improve their chances of graduating and their potential to enter graduate education. The purpose of the funding was to enable undergraduates to participate in a wide range of activities that otherwise would not be available to them. At the same time, other events had catapulted high performance computing into the forefront of academia and research. Mosaic and its successor browsers were transforming the Internet into the super information highway making it possible for widespread dissemination of information. Advances in computer technology, the establishment of the supercomputer centers nine years earlier, the emerging field of computational science and engineering, and the ETA-10 supercomputer acquired with the assistance of NASA GSFC precipitated the development of the High Performance Computing Summer Institute (HPCSI) at Morgan State University. Those involved in the development of the HPCSI proposed to provide greater access for undergraduates to the tremendous high performance computing (HPC) technologies that were finding greater use in the fields of science, engineering, and mathematics.

The success of the HPCSI has met and exceeded the expectations of those involved in its early development. It has been the foundation of Computational Science and Engineering course development and the integration of research into the undergraduate educational experience. It has laid the foundation for faculty research by providing initial funding and student support. It has enabled the University to obtain additional research and development funds. Further, the HPCSI has become a program of excellence providing high performance computing training to undergraduates and promoting the use of

high performance computing technologies in the investigation of scientific and technological phenomena.

In this paper, the role the HPCSI has played in preparing undergraduate students for greater challenges of high technology employment and entrance to graduate schools will be discussed. The impact that it has had on the University and how this concept might be extended to include participation from more HBCU's and tribal colleges will be posed. In addition, some of the research topics that have emanated from the activity will be presented.

2.0 The High Performance Computing Summer Institute

Since its inception, the HPCSI has trained more than eighty students to use advanced computational technologies. A number of these students have graduated and entered the workforce and are now applying high performance computing technologies to real world problems. Others have entered graduate schools where their knowledge and capability of high performance computing can be used in their academic studies and research.

2.1 Program Goals

The purpose of the High Performance Computing Summer Institute has been to introduce undergraduate students to the state-of-the-art in HPC technologies. The goals of the institute since its inception are to:

1) enhance the computing skills and expertise of the students;

2) promote the use of advanced computing technologies in the undergraduate educational experience, research and in the classroom;

3) encourage students to pursue advanced degrees that will allow them to employ high performance computing; and

4) develop graduates that enter the workforce who are capable of applying advanced computing technologies to challenging problems which arise in the workplace.

2.2 Program Description

The HPCSI is an eight-week residential program held each summer for undergraduate students. It is a multi-disciplinary program with two major components: an intensive training course in HPC and individual or team research projects. The training course includes lectures on parallel architectures, parallel computational models, high-speed networking technologies and applications, and scientific visualization. The students are exposed to traditional supercomputing through the use of a parallel vector processor, a Cray J916 supercomputer that serves as a replacement for the ETA-10. In addition, the students have been exposed to the message passing model of parallel computation utilizing a network of workstations this past year.

Research projects are an integral component of the HPCSI. The research projects provide an opportunity for the students to apply technologies and applications in solving real world problems. In addition, the research project component exposes the students to the full range of research activities. Among the activities are:

1) review and employ research techniques in the development of a project with the assistance of a mentor;

2) enhance and improve communication skills through a series of oral presentations;

3) document the project through the writing of a technical paper;

4) present the technical paper at a research symposium at the end of the program; and

5) submit the technical paper for presentations at conferences and/or publication to a journal.

In addition to training and research experiences, the HPCSI also includes weekly seminars, where invited speakers present applications of high-performance computing. These seminars are designed to expose the students to how high performance computing is applied to research in science, engineering, and mathematics. Students attend professional development sessions where they are exposed to technical writing, designing presentations, and techniques in communicating significant aspects of their results.

3.0 Impact of HPCSI on Undergraduate Students

One of the most important benefits of the HPCSI at Morgan State University is the excellent opportunity it provides students to uniquely broaden their training. This effort has enabled students to expand their horizon while at the same time improving their competitiveness for entry into the technological workforce. They are afforded the opportunity to engage in computing on several computational platforms. Through teaming activities, the students learn to investigate problems in their respective fields of study and to gain a greater appreciation of the knowledge that is required from many other disciplines to effectively solve problems of national importance.

The HPCSI has enabled students to participate in HPC through faculty-sponsored research, internships with national centers in HPC, and in the classroom. The faculty-sponsored research begins in the summer and is continued during the academic year. One of the primary mechanisms for the continuation of research is the NASA/Morgan Undergraduate Research Scholars program. The HPCSI has prepared other students to participate as interns at national supercomputer centers, to attend and present at conferences and to be useful to other research projects.

In addition to the students who have benefited from the education related HPC activities, there are those who have gained practical hands-on experience in HPC technologies. These students have served as interns in the Information Systems and Academic Computing Center on campus. They design and install local area networks, enable parallel computing by connecting workstations into clusters or network of workstations, and are trained in the administration of supercomputers and workstations.

Students have expressed the importance of their experiences in the HPCSI through surveys and personal correspondence. One student comments were as follows:

> "Participation in the HPCSI provided an opportunity to solve a practical engineering problem that most undergraduates do not have the opportunity to solve. Courses provide textbook problems that are very simplistic and show only one element of the problem. Through this program I was able to use different computing platforms, a supercomputer running ANSYS software and workstation for post-processing using a structural engineering visualization package (EnSight). These are some of the tools that I will use in my future career. This experience will be invaluable in the remainder of my studies as an undergraduate and as I pursue advanced degrees in engineering. It will strengthen my competitive edge as I enter a professional career."

Another student expressed the impact the HPCI had on his personal development with the following comments:

> "The opportunity afforded me to assist in the design and installation of the computer-based classroom training facility will be invaluable for the rest of my academic and professional career. The experience has reinforced classes that I have taken in computer science, in particular networking. Every student in computer science should have this or a similar experience before graduation."

4.0 Example Research Topics of HPCSI

A number of excellent research topics that had their beginnings as projects in the HPCSI are presently under investigation as faculty research. A number in this group are presently funded through a federal agency. These topics include: *Modeling of Flow Separation around Single and Arrayed Bluff Bodies, Determining Lithology Using An Information Processing Model, Finite Element Analysis of Liquid Storage Tanks: A Parametric Study,* and *Simulation of Solid State Ultraviolet Photodetectors for Earth Observing Instruments*.

Finite Element Analysis of Liquid Storage Tanks: A Parametric Study investigated the dynamic behavior of liquid storage tanks as the tanks are subjected to stresses from natural disasters such as earthquakes and natural elements such as the wind, or those stresses simply caused by flow fluid over the tank. The research project has important implications in many areas. Liquid storage tanks are in widespread use in various branches of industry such as Petroleum and Natural Gas for on-shore storage facilities, the space exploration program for liquid fuel tanks, and for water distribution facilities maintained by public works departments.

One summer, a student research project involved the design of a neural network in electrical engineering applications. As she continued her project during the academic year, she began to construct a model of a neural network that could analyze subsurface data and use the results to classify the various types of rocks present in the strata. The title of her research is *Determining Lithology Using An Information Processing Model* and it classifies rock types by analyzing the data values associated with various rock characteristics. It is proposed to be an alternative to extracting numerous core samples and analyzing each individual layer, thus eliminating the need to perform expensive drilling.

The research project, *Simulation of Solid State Ultraviolet Photodetectors for Earth Observing Instruments*, was instrumental in the advisor submitting and receiving an award for research from the NASA GSFC. As a team research effort in the HPCSI, the purpose of the project was to employ high performance computing technologies to simulate the material properties, device topologies, and manufacturabilty of the photodetectors. Its significance to NASA stems from the agency's need for compact, lightweight, high performance, low cost photodetectors to build ultraviolet (UV) instruments for future space missions.

5.0 Extension of Model to other HBCUs and Tribal Colleges

We feel that this model is an excellent one and that it can be easily extended to include a larger number of HBCUs, HSIs and the Tribal Colleges. MUSPIN member institutions are excellent candidates for inclusion. Participation from a few of its members has already begun; included among those are Central State University, Elizabeth City State University, Jackson State University, North Carolina A&T, and Tennessee State University.

In most instances, the participation has been through individual students who are paired with a faculty mentor at Morgan State University. While this approach enables the students to gain invaluable experiences during the summer, it has not allowed the student to continue to develop once the student returned to his/her home institution. An alternative to this approach is for participation by both faculty and students from a visiting university. In the summer of 1997, participants from Central State University of Ohio used this approach.